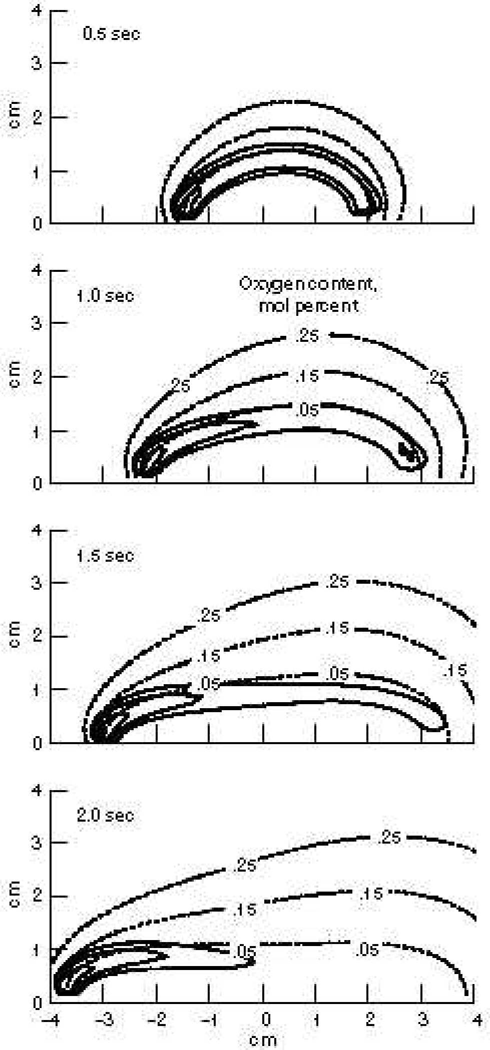

Radiative Ignition and the Transition to Flame Spread Investigated in the Japan Microgravity Center's 10-sec Drop Shaft

In space, many things react differently because of the lack of gravity. One area of concern is how fire ignites and reacts in a microgravity environment. Fires in spacecraft pose significant dangers to the crew: toxic products could quickly poison the atmosphere and be difficult to remove, large-scale production of gases at high temperatures could overpressurize the spacecraft, and extinguishing systems might damage the electrical systems. Although momentary ignitions due to electrical short-circuiting or overheating might be an acceptable and recoverable hazard, a transition from an ignition to large-scale fire growth is an unacceptable risk. To stop this transition, the environmental conditions that allow transition must be avoided. These conditions are not yet well known because, on Earth, buoyant flow removes the products of combustion (carbon dioxide and water vapor) and brings in fresh oxygen for the flame. In the microgravity environment aboard spacecraft, the predominant flows are the very slow air ventilation flows rather than buoyancy.

The Radiative Ignition and Transition to Spread Investigation (RITSI) is a shuttle middeck Glovebox combustion experiment developed by the NASA Lewis Research Center, the National Institute for Standards and Technology (NIST), and Aerospace Design and Fabrication (ADF). It is scheduled to fly on the third United States Microgravity Payload (USMP-3) mission in February 1996. The objective of RITSI is to experimentally study radiative ignition and the subsequent transition to flame spread in low gravity in the presence of very low speed air flows in two- and three-dimensional configurations.

Toward this objective, a unique collaboration between NASA, NIST, and the University of Hokkaido was established to conduct 15 science and engineering tests in Japan's 10-sec drop shaft. For these tests, the RITSI engineering hardware was mounted in a sealed chamber with a variable oxygen atmosphere. Ashless filter paper was ignited during each drop by a tungsten-halogen heat lamp focused on a small spot in the center of the paper. The flame spread outward from that point. Data recorded included fan voltage (a measure of air flow), radiant heater voltage (a measure of radiative ignition energy), and surface temperatures (measured by up to three surface thermocouples) during ignition and flame spread. In addition, color video and 35-mm film pictures were taken during the drop.

Data from these tests are still being reduced and analyzed, but some observations can be reported. Radiative ignition in low gravity was successfully achieved for the first time. Preliminary findings indicate that the spread of flames upwind into fresh oxygen was enhanced by the very low speed flows, as was anticipated from model predictions and previous experimental results (refs. 1 and 2). Downwind flame spread was less robust because of the presence of the upwind flame, which vitiates the atmosphere for the downwind flame, in agreement with modeling results, as shown in the figure (ref. 1).

Flame transition to spread after radiative ignition. Gas flow enters from the left. Solid lines are reaction contours, which can be compared to flame shape; and dashed lines are oxygen concentration contours. Note the upstream flame (to the left) is almost immediately more vigorous and that the downstream flame dies away because of the oxygen "shadow" cast by the upstream flame.

References

1. McGrattan, K.B., et al.: Effects of Ignition and Wind on the Transition to Flame Spread in a Microgravity Environment. Accepted for publication in Combustion and Flame, 1996.

2. Olson, S.L.: Mechanisms of Microgravity Flame Spread Over a Thin Solid Fuel: Oxygen and Opposed Flow Effects. Combust. Sci. Tech., vol. 76, 1991, pp. 233-249.